

# NAG Library Function Document

## nag\_rand\_normal (g05skc)

### 1 Purpose

nag\_rand\_normal (g05skc) generates a vector of pseudorandom numbers taken from a Normal (Gaussian) distribution with mean  $\mu$  and variance  $\sigma^2$ .

### 2 Specification

```
#include <nag.h>
#include <nagg05.h>
void nag_rand_normal (Integer n, double xmu, double var, Integer state[],
                     double x[], NagError *fail)
```

### 3 Description

The distribution has PDF (probability distribution function)

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right).$$

nag\_rand\_normal (g05skc) uses the algorithm of Wichura (1988).

One of the initialization functions nag\_rand\_init\_repeatable (g05kfc) (for a repeatable sequence if computed sequentially) or nag\_rand\_init\_nonrepeatable (g05kgc) (for a non-repeatable sequence) must be called prior to the first call to nag\_rand\_normal (g05skc).

### 4 References

Kendall M G and Stuart A (1969) *The Advanced Theory of Statistics (Volume 1)* (3rd Edition) Griffin

Knuth D E (1981) *The Art of Computer Programming (Volume 2)* (2nd Edition) Addison–Wesley

Wichura (1988) Algorithm AS 241: the percentage points of the Normal distribution *Appl. Statist.* **37** 477–484

### 5 Arguments

- |    |  |              |
|----|--|--------------|
| 1: | <b>n</b> – Integer   | <i>Input</i> |
|    | <i>On entry:</i> $n$ , the number of pseudorandom numbers to be generated. |              |
|    | <i>Constraint:</i> $n \geq 0$ .  |              |
| 2: | <b>xmu</b> – double  | <i>Input</i> |
|    | <i>On entry:</i> $\mu$ , the mean of the distribution.                     |              |
| 3: | <b>var</b> – double  | <i>Input</i> |
|    | <i>On entry:</i> $\sigma^2$ , the variance of the distribution.            |              |
|    | <i>Constraint:</i> $\text{var} \geq 0.0$ .                                 |              |

- 4: **state** $[dim]$  – Integer *Communication Array*  
**Note:** the dimension, *dim*, of this array is dictated by the requirements of associated functions that must have been previously called. This array **MUST** be the same array passed as argument **state** in the previous call to `nag_rand_init_repeatable` (g05kfc) or `nag_rand_init_nonrepeatable` (g05kge).  
*On entry:* contains information on the selected base generator and its current state.  
*On exit:* contains updated information on the state of the generator.
- 5: **x** $[n]$  – double *Output*  
*On exit:* the *n* pseudorandom numbers from the specified Normal distribution.
- 6: **fail** – NagError \* *Input/Output*  
The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

## 6 Error Indicators and Warnings

### NE\_ALLOC\_FAIL

Dynamic memory allocation failed.

See Section 2.3.1.2 in How to Use the NAG Library and its Documentation for further information.

### NE\_BAD\_PARAM

On entry, argument  $\langle value \rangle$  had an illegal value.

### NE\_INT

On entry,  $n = \langle value \rangle$ .

Constraint:  $n \geq 0$ .

### NE\_INTERNAL\_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

An unexpected error has been triggered by this function. Please contact NAG.

See Section 2.7.6 in How to Use the NAG Library and its Documentation for further information.

### NE\_INVALID\_STATE

On entry, **state** vector has been corrupted or not initialized.

### NE\_NO\_LICENCE

Your licence key may have expired or may not have been installed correctly.

See Section 2.7.5 in How to Use the NAG Library and its Documentation for further information.

### NE\_REAL

On entry,  $var = \langle value \rangle$ .

Constraint:  $var \geq 0.0$ .

## 7 Accuracy

Not applicable.

## 8 Parallelism and Performance

nag\_rand\_normal (g05skc) is threaded by NAG for parallel execution in multithreaded implementations of the NAG Library.

Please consult the x06 Chapter Introduction for information on how to control and interrogate the OpenMP environment used within this function. Please also consult the Users' Note for your implementation for any additional implementation-specific information.

## 9 Further Comments

None.

## 10 Example

This example prints five pseudorandom numbers from a Normal distribution with mean 1.0 and variance 1.5, generated by a single call to nag\_rand\_normal (g05skc), after initialization by nag\_rand\_init\_repeatabl (g05kfc).

### 10.1 Program Text

```

/* nag_rand_normal (g05skc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */
/* Pre-processor includes */
#include <stdio.h>
#include <math.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg05.h>

int main(void)
{
    /* Integer scalar and array declarations */
    Integer exit_status = 0;
    Integer i, lstate;
    Integer *state = 0;

    /* NAG structures */
    NagError fail;

    /* Double scalar and array declarations */
    double *x = 0;

    /* Set the distribution parameters */
    double xmu = 1.0e0;
    double var = 1.5e0;

    /* Set the sample size */
    Integer n = 5;

    /* Choose the base generator */
    Nag_BaseRNG genid = Nag_Basic;
    Integer subid = 0;

    /* Set the seed */
    Integer seed[] = { 1762543 };
    Integer lseed = 1;

    /* Initialize the error structure */
    INIT_FAIL(fail);

```

```

printf("nag_rand_normal (g05skc) Example Program Results\n\n");

/* Get the length of the state array */
lstate = -1;
nag_rand_init_repeatabe(genid, subid, seed, lseed, state, &lstate, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_rand_init_repeatabe (g05kfc).\n%s\n",
        fail.message);
    exit_status = 1;
    goto END;
}

/* Allocate arrays */
if (!(x = NAG_ALLOC(n, double)) || !(state = NAG_ALLOC(lstate, Integer)))
{
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
}

/* Initialize the generator to a repeatable sequence */
nag_rand_init_repeatabe(genid, subid, seed, lseed, state, &lstate, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_rand_init_repeatabe (g05kfc).\n%s\n",
        fail.message);
    exit_status = 1;
    goto END;
}

/* Generate the variates */
nag_rand_normal(n, xmu, var, state, x, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_rand_normal (g05skc).\n%s\n", fail.message);
    exit_status = 1;
    goto END;
}

/* Display the variates */
for (i = 0; i < n; i++)
    printf("%10.4f\n", x[i]);

END:
    NAG_FREE(x);
    NAG_FREE(state);

    return exit_status;
}

```

## 10.2 Program Data

None.

## 10.3 Program Results

nag\_rand\_normal (g05skc) Example Program Results

```

1.4272
-0.5254
1.8109
2.0232
-0.5380

```

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